MODIS DATA STUDY
TEAM PRESENTATION

March 22, 1991

AGENDA

1. Action Items
2. The ICC's Role in Checking Instrument Status
3. Ocean Science Proposals, Phase I: Carder
4. Delivery of Revised Level-1A Processing System

ACTION ITEMS:

03/08/91 [Lloyd Carpenter; Team]: Prepare information for presentation by V. Salomonson at Data Compression Workshop. The information should emphasize the data requirements of MODIS, especially those amenable to data compression techniques. Due March 22, 1991. STATUS: Delivered to Daesoo Han 03/21/91 for presentation to V. Salomonson at the MODIS Technical Team Meeting.

03/15/91 [Watson Gregg]: Review the most recent version of the ECS Requirements Specifications (Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System; Fifth Preliminary, 14 December 1990) to determine if the ICC is required to check the instrument command history against the telemetered status. Due March 22, 1991. STATUS: Report in this week's handout.

03/15/91 [Watson Gregg]: Revise title and date of anchor point accuracies report and deliver to Daesoo Han and Wayne Esaias. STATUS: Open.

03/15/91 [Team]: Delete the requirement to append Instrument Status Information from Level-1A Processing System. STATUS: Revised Level-1A Processing System Report delivered this week. Closed.

ICC Role in Checking Instrument Status

A question was raised at the MODIS Data Study Team meeting of March 15, 1991, as to what are the latest requirements of the ICC to check instrument status. The question arose because the requirement to compare the Instrument Status Information with the telemetered status information was deleted from the MODIS Level-1A processing System.

The Functional and Performance Requirements Specification for the Earth Observing System Data and Information System (EOSDIS) Core System, hereafter called the ECS Specs, defines the ICC as

"An Instrument Control Center (ICC) is a functional entity responsible for the command and operation of a single EOS instrument. It monitors health and safety of its instrument, generates commands, and coordinates planning and scheduling inputs with the EOC." (Page A-11).

Section 6.5.2.1.2 states under the Telemetry Processing Service,

"The ICC provides health and safety monitoring for its instrument. It receives real-time or playback observatory housekeeping data and instrument engineering data directly from CDOS. For some instruments, instrument engineering data received from CDOS may be embedded in science packets, from which the ICC will have to extract the instrument engineering data. The ICC extracts the relevant platform parameters and instrument housekeeping data from the observatory housekeeping data stream. The ICC uses these data for both short-term instrument health, safety, and performance monitoring activities, and for instrument trend monitoring." (Page 6-46).

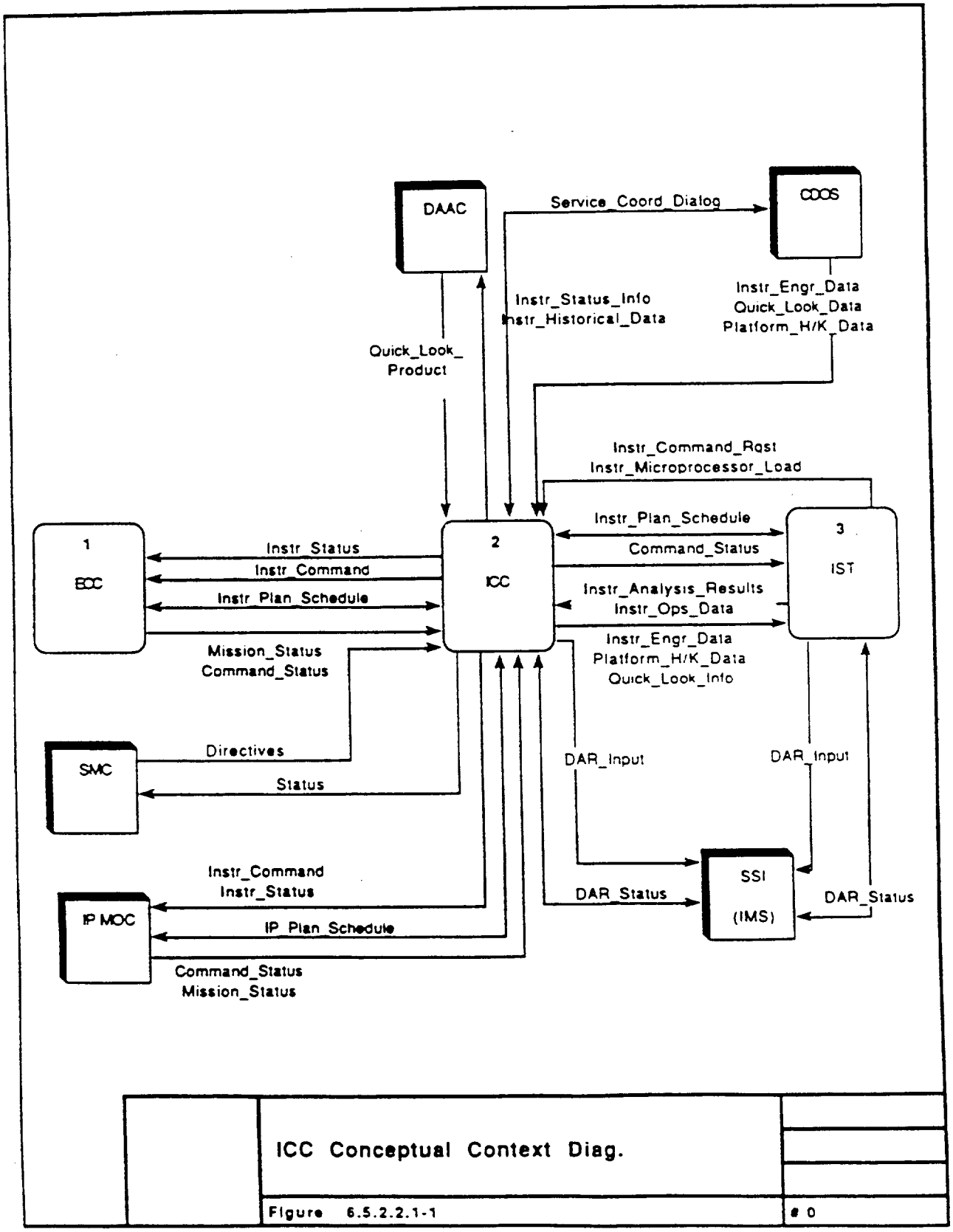
Instrument Housekeeping Data is defined as

"A subset of Instrument Engineering Data which is directly related to instrument health and safety. Examples are on/off status, mode status, and critical temperatures." (Page A-12).

Figure 6.5.2.2.1-1 shows the ICC Concept in relation to other EOSDIS entities. Instrument Status Information is routed directly to the ICC from CDOS, as is other instrument and platform data. Instrument Status Information is defined as "instrument status information resulting from the ICC's analysis of instrument data, for archival." (Page 6-55). Instrument Status is defined as "high-level instrument status information, obtained from instrument

telemetry, including identification of anomalous events." (Page 6-52).

Although comparisons between the Instrument Status Information and status contained in the Level-0 engineering data are not specifically referred to in the ECS Specs, the health and safety monitoring function of the ICC strongly points to the responsibility of the ICC in this area. Deletion of such checking from the Level-1A processing system will therefore not result in a complete absence of status checks -- it is the ICC's responsibility to perform such monitoring. One may conclude that it is redundant for the MODIS data system to perform the same functions.



ICC Conceptual Context Diag.

Figure 6.5.2.2.1-1

0

MODIS Team Member Proposal
Data Requirements Form

Investigator: Carder , Kendall L.

Output Product(s): Algorithms to quantify
(1) Case II chlorophyll
(2) Case II degradation products (absorption coefficients)
(3) Total dissolved organic carbon
(4) Backscattering coefficient at 565 nm
(5) Case II suspended sediments pg 5
(6) Flag-type algorithm to designate Case II waters pg 6,20

Resolution (Time):
(Space): Pixel pg 5

Domain (Space): 5% of all cloud-free water pixels or 2% of total pixels pg 5

At Launch: (1) through (6) pg 6, 7

Post Launch: Test, verify, modify and establish error limits. pg 7
Case 2 algorithms for more complicated environments pg 8

MODIS-N/T: T

Input Data: MODIS Level-1.5 data and in situ calibration/verification optical data. pg 4

Spectral Bands Required:
Resolution (Time):
(Space):

Ancillary Data Required
(Type and Source): Pre-Launch: CZCS, SeaWifs, and OCTS/ADEOS satellite data, archived and new in situ optical and constituent data sets (USF derived) pg 4

Pre-Launch: CZCS **Size (Mbytes):** 50 scenes per year
SeaWifs and OCTS/ADEOS 200 scenes each per year pg 18

Post-Launch: **Size (Mbytes):**

Algorithm Complexity (floating point operations/scan):

Algorithm Memory Required (Mbytes):

Data Storage Required (Mbytes/scan):

Look-Up Tables Required: The data needed by DIS to flag Case 1 and Case 2 waters will include six or seven channels of Level 1.5 data at 12 bits, and a look-up table for the algorithm. pg 19

Size (Mbytes):

Lines of Code:

Language Expected:

Accessory Output Products (e.g., field experiment data):

Pre-Launch: **Size (Mbytes):**

Post-Launch: **Size (Mbytes):**

Expected Need of SDST (Pre- or Post-Launch):

---

ost-Launch Expected Growth:

Quality Assessments:

Special Tilt Modes Required:

Notes:

The P.I. will provide algorithms for, and help develop Level-2 data products for Case 2 waters. He will also help develop an efficient algorithm for flagging regions requiring processing beyond the standard team Case 1 algorithm. pg 18

A T-1 line is requested of EOSDIS from Miami to USF to speed MODIS data transfer. pg 19

Level 2 maps with at least 10-bit resolution would be required as output products from EOSDIS for the Case 2 waters once verification activities are complete. pg 20

Level 2a processing for Case 2 waters will be experimental and can only be accurately performed for a region (e.g. river plume) that has been studied for its site-specific character. pg 20

MODIS LEVEL-1A DATA PROCESSING SYSTEM REVISION 1

MODIS DATA STUDY TEAM

March 23, 1991

PREFACE

This revision deletes the previous requirement to append Instrument Status Information to the Level-0 data. This information will not be available for 2 days after the Level-0 data without imposing a requirement on the Instrument Control Center (ICC). The Instrument Status Information was originally appended to verify the operating mode; however, according to the ECS Specifications, Fifth Preliminary, such verification is the ICCs responsibility.

TABLE OF CONTENTS

Page

Preface ii

MODIS Level-1A Data System Functional Requirements 1

Overview 1
Requirements List 2
Data Dictionary 5

MODIS Level-1A Data Processing System 8

Overview 8
Context Diagram and Data Flow Diagrams 11
Data Dictionary 22
Assumptions List 38
External Interface Document 41
Granule Structure 45
Data Quality 47

Bibliography 48

MODIS LEVEL-1A PROCESSING SYSTEM FUNCTIONAL REQUIREMENTS: OVERVIEW

The MODIS (Moderate Resolution Imaging Spectrometer) Level-1A data processing system is designed to convert Level-0 data (raw, time-ordered instrument data) into the Level-1A data product (Level-0 data transformed reversibly and packaged with needed ancillary, engineering, and auxiliary data). The system we have designed is intended to meet the science requirements of the sensor and the ECS (EOSDIS Core System) Requirements Specifications (see Bibliography).

The primary purposes of Level-1A data processing are to:

1. Prepare the data for Level-1B processing, where the data will be navigated and calibrated,

2. Provide a reversible, "pure" dataset as a potential backup to Level-0 data, and

3. Facilitate characterization and use by users.

These three primary purposes lead to the three primary functions of Level-1A processing:

1. Append spacecraft ancillary data to the MODIS Level-0 data to facilitate navigation and calibration,

2. Create the Level-1A structure (place data into a granule).

3. Produce metadata.

In addition, the Level-1A system will respond to control, and produce processing status information. There will not be a browse product for Level-1A, since there is no science requirement for it. The system will also respond to three potential processing modes: 1) standard, 2) reprocessing, and 3) quick-look data. We have assumed that quick-look data may not be time-ordered, unlike the standard processing and reprocessing modes.

We have designed the Level-1A processing system with a conservative approach. Level-1A does a minimum amount of processing in order to assure a coherent, complete dataset that is easily reversible. This concept is intended to assure the existence of a relatively "pure" MODIS database in the event substantial reprocessing is required at a later date or in the event Level-0 data are somehow lost.

The MODIS Level-1A Functional Requirements statement follows, with a data dictionary. In both, statements and definitions were taken verbatim from the ECS Requirements Specifications where possible. The entire design uses terminology and definitions from this document wherever possible to facilitate commonality.

C. PROCESSING STATUS INFORMATION

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL GENERATE FAULT INDICATIONS:

(Page 7-22, 3PGS-00320: The PGS shall display detected faults to the system operators.)

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL PROVIDE STATUS INFORMATION

(Page 7-22, 3PGS-00380: The PGS shall monitor its internal operations and generate a status report periodically.)

D. OUTPUT

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL PRODUCE:

1. Level-1A Data Products

   (Page 7-13, 3DAAC00070: The DAAC shall generate Levels 1, 2, 3, and 4 data products, archive, manage, quality check and account for archived data products.)

2. Processing Log

   (Page 7-22, 3PGS-00360: The PGS shall generate a PGS Processing Log periodically that accounts for all data processing activities.)

3. Metadata

   (Page 7-24, 3PGS00510: The PGS shall have the capability to generate metadata according to the algorithms provided by the scientists and associate this metadata with each standard data product generated.)

   (Page 7-14, 3DAAC00220: The DAAC shall generate browse data and metadata for routing to the requested users, through the coordination of IMS.)

4. Quick-Look Product (Level-1A)

   (Page 7-13, 3DAAC00050: The DAAC shall provide the ICC with quick-look products for further evaluation of instrument operations and data quality.)

   (Page 7-14, 3DAAC00260: The DAAC shall produce quick-look products for priority transfer to the ICCs.)

E. OTHER

MODIS LEVEL-1A PROCESSING SHALL BE ACCOMPLISHED USING TWO DISTINCT SETS OF STAND-ALONE SOFTWARE: ONE SET TO SUPPORT MODIS-N PROCESSING AND ONE SET TO SUPPORT MODIS-T PROCESSING.

(Unreferenced)

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL BE CAPABLE OF REPROCESSING

(Page 7-24, 3PGS-00540: The PGS shall reprocess specified science data using new and/or updated algorithms provided by the scientists.)

(Page 7-24, 3PGS-00550: The PGS shall reprocess science data using the original or updated (provided by the scientists) calibration coefficients.)

THE MODIS LEVEL-1A PROCESSING SYSTEM SHALL BE CAPABLE OF PRODUCING LEVEL-0 DATA FROM LEVEL-1A DATA

(Requirement inferred from definition of Level-1A data)

MODIS LEVEL-1A PROCESSING SYSTEM
FUNCTIONAL REQUIREMENTS: DATA DICTIONARY

In the following, statements enclosed in quotations are quoted verbatim from the ECS Requirements Specifications document (reference may be found at the end of the data dictionary). Statements not enclosed in quotations are attributed to the MODIS Data Study Team.

Ancillary Data: "Any data, other than standard products, that are required as input in the generation of a standard product. This may include ancillary data from the EOS platforms and the attached payloads, as well as non-EOS ancillary data. All ancillary data are received by the PGS from the DADS." (Page 7-17). For Level-1A, ancillary data includes the Spacecraft Ancillary Data. For Level-1A, Ancillary data does not include Locally Maintained Databases.

Anomaly Reports: A report identifying a discrepancy between two or more sources of information. (Unreferenced).

Audit Trail: A record that describes the processing history of data and its identification. Contained within the metadata. (Unreferenced).

Completeness: A data quality indicator determining whether a particular data increment is present in finished form or whether there are missing items. (Unreferenced).

Control: "The PGS shall provide a scheduler with the capacity to perform the following functions, at a minimum: (a) Add tasks to the job queue, (b) Allocate tasks among processors, (c) Initiate execution of tasks in the job queue, (d) Suspend execution of tasks, (e) Resume execution of a suspended task, (f) Cancel execution of tasks, and (g) Request and verify the staging and/or destaging of data stored in the DADS.)" (Page 7-21). In addition are (h) Select processing mode and (i) Request processing status information. Two types of cancel operations are provided: (1) non-graceful (no output generated) and (2) graceful (output up to the cancellation point generated).

Data Quality Check: The process by which data quality information is generated. (Unreferenced).

Data Quality Information: Information on data quality, including existence, completeness, and the presence of anomaly reports, at a minimum. (Unreferenced).

Existence: A data quality indicator determining whether a particular increment of data is present or absent. (Unreferenced).

Fault Indication: An unsolicited flag denoting that a hardware or software error has occurred (e.g., a disk drive failed during data transfer or data header identifiers are not correct), or an "alarm" or "event." (Unreferenced).

Instrument Data: "Data specifically associated with the instrument, either because it was generated by the instrument or included in data packets identified with that instrument. These data consist of instrument science and engineering data, and possibly ancillary data. These data may be assembled for transmission by the instrument, or by an on-board processor of the instrument data." (Page A-9). "Data created by an instrument including scientific measurements and any engineering or ancillary data which may be included in the instrument data packets." (Page A-9).

Level-0 Data: "Raw instrument data at original resolution, time-ordered, with duplicities [sic] removed." (Page A-4) .

Level-1A Data Product: "Level-0 data, which may have been reformatted or transformed reversibly, located to a coordinate system, and packaged with needed ancillary, engineering, and auxiliary data." (Page A-4). Includes instrument data, a header, and data quality information.

Metadata: "Information which is obtained from datasets, and which provides an understanding of the content or utility of the dataset. Metadata may be used to select data for a particular scientific investigation." (Page A-11) Metadata will include an audit trail. (Page 7-18).

Processing Log: "Periodically accounts for all data processing activities." (Page 7-22, 3PGS-00360). A record of the time-ordered processing events. An event may be the completion of the processing activity or the generation of an anomaly report.

Processing Mode: There are three types:

a. Standard Product Processing: "The PGS shall have the capability to produce each standard product as specified in that product's Standard Product Specification." (Page 7-23, 3PGS-00470).

b. Reprocessing: "The PGS shall reprocess specified science data using new and/or updated algorithms provided by the scientists." (Page 7-24, 3PGS-00540).

c. Quick-Look Data Processing: "The PGS shall send the DADS quick-look data for routing to the appropriate destination (e.g., ICC, SCF). Quick-look data shall contain the following information at a minimum: (a) Product identification, (b) quick-look data, (c) associated metadata, (d) process facility identification, and (e) current date and time." (Page 7-30, 3PGS-01260).

Processing Performance: A statement of the amount of data processed; will include a record during processing (dynamic status) and a post-event record (static status). (Unreferenced).

Processing Status Information: "Information regarding schedules, hardware and software configuration, exception conditions, or processing performance." (Page 7-18). The Level-1A Processing System is concerned only with fault (exception) conditions and processing performance.

Quick-Look Data (Level-0): "Real-time or priority playback data which receive minimal processing and are forwarded to the user for his review/use. The user may provide additional processing to suit his requirements." (Page A-14). "Data Received during one TDRSS contact period which have been processed to Level-0 (to the extent possible for data from a single contact). This is data that have been identified as requiring priority processing on the order of a few hours. It is routed to the PGS from the DADS." (Page 7-18). At Level-0, these data are not necessarily time-ordered, complete, nor have duplicates been removed, but are at original resolution.

Quick-Look Product (Level-1A): "Quick-look data that has been processed by a PGS prior to being sent to an ICC." (Page 7-35). At Level-1A, Quick-Look Products are not necessarily time-ordered, with duplicates removed, but are at original resolution, and are packaged with necessary ancillary and engineering data. The product is reversible to Level-0 Quick-Look Data. It includes instrument data, a header, but may not have data quality information.

Spacecraft Ancillary Data: "Data available on board a spacecraft, derived from spacecraft parameters, or resulting from the on-board substitution of backup spacecraft parameters, but not produced by an instrument, which are needed for the processing or interpretation of instrument data. Spacecraft ancillary data comprises data referred to as "engineering", "core housekeeping" or "subsystem" data and includes parameters such as orbit position and velocity, attitude and its rate of change, time, temperatures, pressures, jet firings, water dumps, internally produced magnetic fields, and other environmental measurements." (Page A-15).

MODIS LEVEL-1A PROCESSING SYSTEM OVERVIEW

INTRODUCTION

The primary functions of the Level-1A data processing system are to 1) append spacecraft ancillary data and MODIS instrument status information to the MODIS Level-0 data, and 2) produce metadata. We have designed a Level-1A processing system to meet these goals and to meet the functional requirements of the ECS Requirements Specifications. The processing system is designed using computer-structured engineering methodologies, specifically, Computer-Aided Software Engineering (CASE) tools.

The following description of the MODIS Level-1A processing system contains 1) a narrative description of the processing system and flow, 2) a detailed Context Diagram and Data Flow Diagrams, 3) a complete Data Dictionary defining in detail the terms used in the Data Flow Diagrams, 4) a formal list of the key assumptions upon which the design is based, 5) an External Interface document describing the interrelations between the MODIS processing system and external entities, 6) a description of the format of the data granule, and 7) a formal list of the data quality information generated.

DEFINITIONS OF DATA INCREMENTS

There are three data increments used in the Level-1A design:

1. Packets
2. Scan cubes
3. Granules

Packets are the smallest increment. They consist of band-interleaved pixels, i.e., a small number of pixels ($\sim$ 18 for MODIS-T) with all of the wavelength information. A scan cube is an assemblage of packets, such that all along-track and across-track pixels are included. The scan cube (Figure 1) has the dimensions of x, y, z, where x is across-track, y is along-track, and z is wavelength. Thus for MODIS-T a scan cube would have the dimensions 1007 by 30 by 34. Finally a granule is an assemblage of scan cubes. Its size is as yet undefined (awaiting a requirements statement from the MODIS Science Team). As of now we envision it to be larger than the scan cube but no larger than an orbit of data. The actual format of the granule is described later.

GENERAL DESCRIPTION OF THE PROCESSING SYSTEM

Figure 2 is a Context Diagram that summarizes the processes and external control involved in the MODIS Level-1A data product generation system. Symbols are defined in Figure 3. There are two types of flows: 1) control flow and 2) data flow. Control flow is the passing of messages to and from the system. These messages may indicate status (events and post-processing accounting), in-processing queries (dynamic status requests), or errors (alarms). Data flows are the actual passing of data from one process or storage area to the next.

Level-1A MODIS processing is primarily a batch-oriented process in which the packets of instrument data from the satellite (Level-0 data) and ancillary data are stored in an external (to this process) database manager managed by ECS (called Scheduling, Control and Accounting, or SCA), and are supplied by the SCA. The MODIS Level-1A processing system receives the MODIS Level-0 instrument data, verifies the packets and the data within the packets, appends instrument status information and spacecraft ancillary data, formats the MODIS data into the Level-1A data structure with headers and creates associated metadata.

The MODIS processing system is required to handle three different processing modes: 1) standard processing, 2) reprocessing, and 3) quick-look data processing. These processing modes may differ in the types of functions and format of data. For example, the reprocessing mode will not begin with Level-0 data, but rather Level-1A data. Thus, the granule structure initialization need not be performed. In addition, the system must respond to control by the SCA (including external queries, events, and alarms) and produce status information. These requirements add a layer of control functions to the basic data processing function. The Level-1A processing system is required to be reversible, i.e., to re-create Level-0 data. The system presented here meets this requirement, but the actual process of reversibility is covered by another process not described here.

DETAILED DESCRIPTION OF THE PROCESSING SYSTEM

Figure 4 represents the highest level of processing, called the "Level-A" diagram. The remaining figures are expansions on the data processes and control transforms indicated at the higher level; these are called "Level-B" diagrams.

The first actions in the Level-1A system to occur are control flow. The SCA controls the processes of the MODIS Level-1A product generation program, as illustrated in Figure 4. The SCA initiates the MODIS Level-1A program by generating a "start" message that says all information necessary for the MODIS Level-1A system is available, and the processing may begin. Three datasets are required: the Level-0 data with accounting and quality information, spacecraft ancillary data (ephemeris, attitude, and possibly science or engineering data from other sensors on the platform), and the MODIS Instrument Status Information. If the datasets are not available, an "initialization problem" indication is sent to the control function to be passed to the SCA for resolution. The "start" message also contains the data types, sizes, instrument identification, dataset file names and locations, and processing mode.

At this stage and during all stages of processing, the SCA can send "dynamic status request" and "termination" messages to the MODIS processor. The control functions are shown in Figure 5. For example, upon normal completion of the processing, a termination message is sent to the SCA. The MODIS Level-1A processor will then post an entry into the EOSDIS (or MODIS) Processing Log external entity which allows a time-based accounting of the processing events as they occur and can be used as a definitive audit trail to determine what has been processed and when. During the processing of the MODIS instrument data, two types of control indications can be generated: "events" and "alarms". These control

indicators are passed to the SCA for further action. The SCA, not the MODIS process, makes the decision to abort this MODIS task if a problem is sufficiently severe.

After receiving a "start" message, the MODIS system initializes the data structure (Figure 6). This process has two functions: (1) incoming packets are verified and (2) memory and disk space is allocated. At this stage the granule and metadata structures are created. The structures are filled with "invalid" data values which are later replaced by actual MODIS data. Initialization occurs only once per granule of data processed. Granule and metadata initialization must be complete and input data must be staged in the DADS before the processing of MODIS data packets can begin.

Level-1A processing occurs in three stages: 1) packet processing, 2) scan cube processing, and 3) granule processing.

1. Packet Processing Packet processing verifies packets, compares instrument status from the Instrument Status Information with information contained in the selected packet, and appends operating system time, called "wall time" (Figure 7). Packet processing also places packets into their correct (time-ordered) locations in the granule structure (Figure 8).

2. Scan Cube Processing As the packets are placed into the granule, they eventually form a completed scan cube. When a scan cube is filled with packets, the scan cube is considered complete, and scan cube processing may begin (Figure 9). At this stage of processing, scan cube data are verified, instrument status information and spacecraft ancillary data are appended to the cube, and the scan cube header is created. The valid items of the metadata are also created and sent to the metadata structure.

3. Granule Processing When all scan cubes of data have been filled, the granule is complete. The granule header is then generated and appended to the granule and the metadata product is finalized (Figure 10). The granule and metadata are then transmitted to the Product Management Service (PMS), under control of the ECS. The MODIS Level-1A system sends a "data processed" message to the SCA and is ready either for termination or to process another granule.

Note that in the system design, individual packets are placed into the granule structure, and the scan cube is created as a consequence of filling up the granule. This method allows for the handling of non-time-ordered data in a very easy fashion. Although standard Level-0 data is required to be time-ordered, this method assures the integrity of Level-1A data at no cost in processing. Furthermore, the system is adapted to other processing modes, such as quick-look data, which may not be time-ordered. This system also removes duplicate packets.

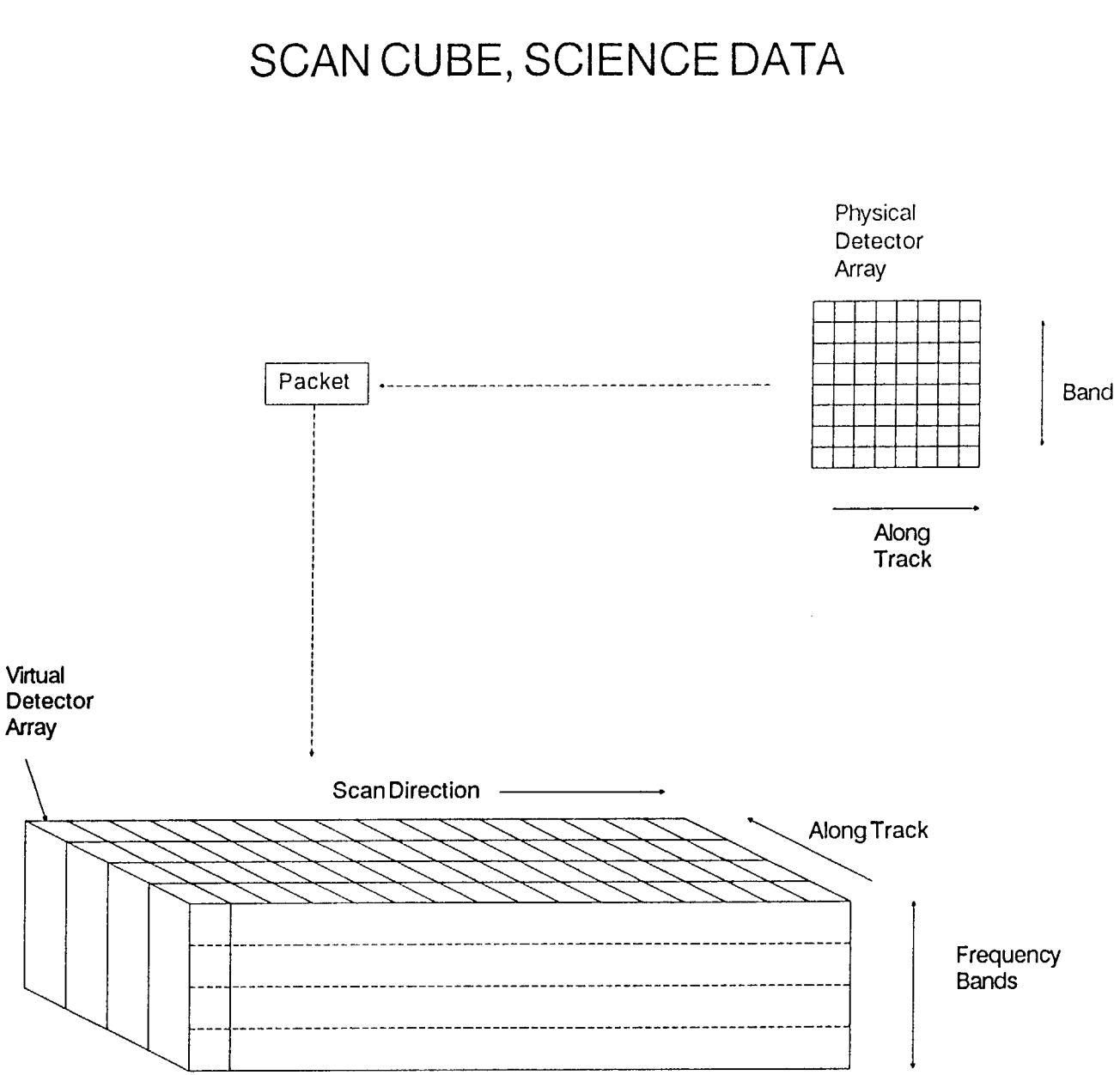


Figure 1. Visual representation of a scan cube.

ject : \ECPLUS\MODIS-1A\
t : context
nam context.trg
M ed : 01-17-1991

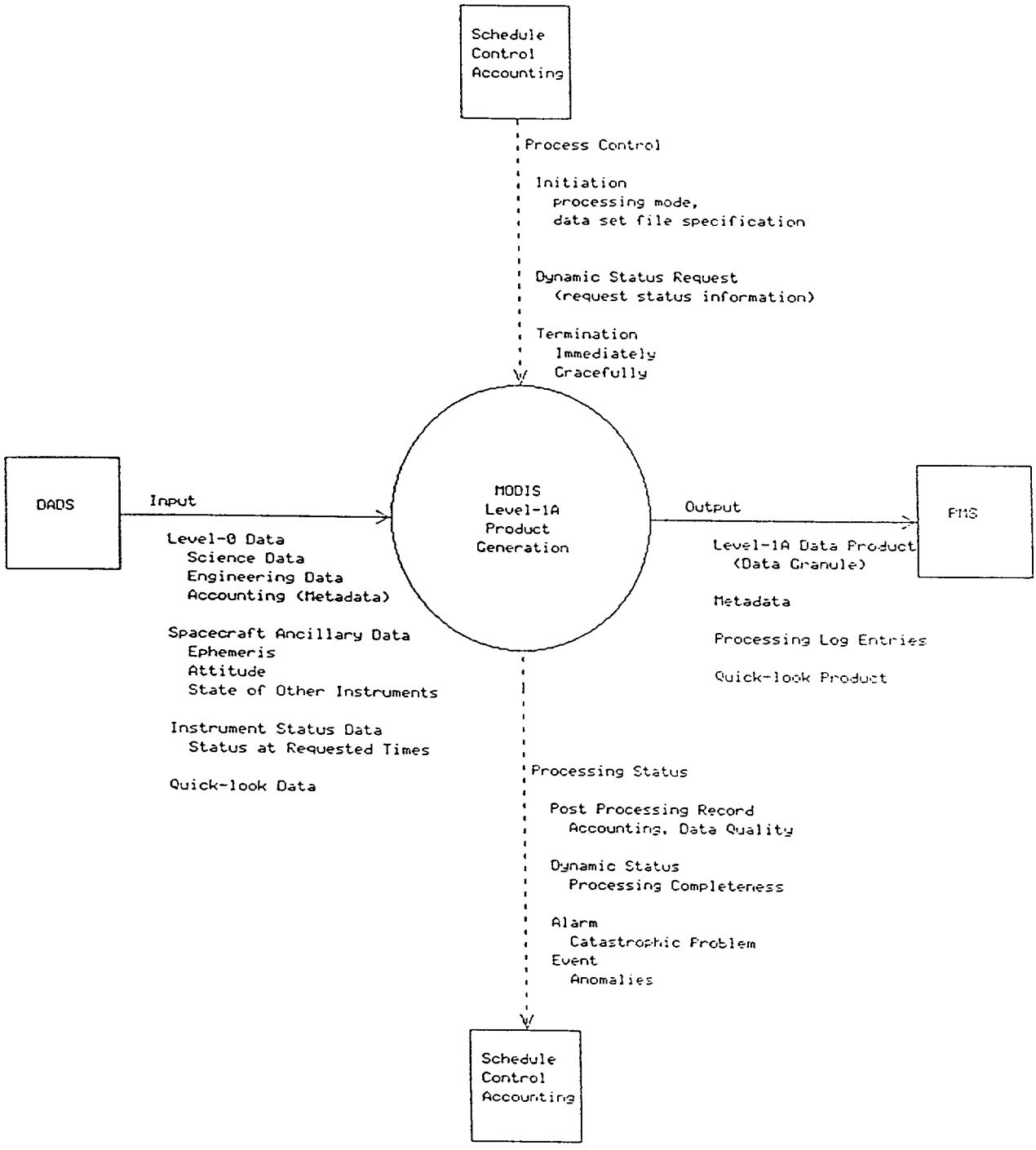


Figure 2. Context diagram for MODIS Level-1A processing system.

```
ect : \ECPLUS\MODIS-IA\
t : sample
ne     sample.trg
Mo   ied : 01-16-1991
```

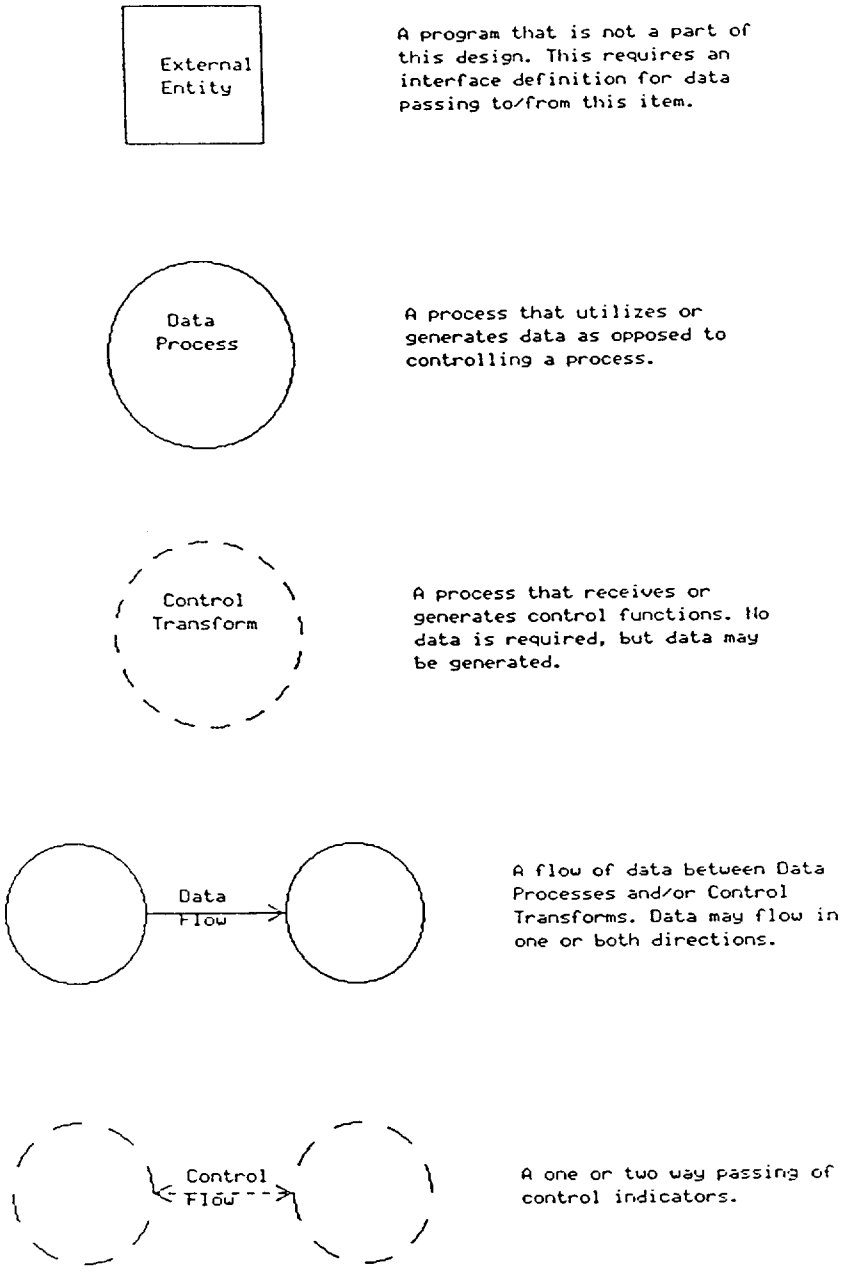


Figure 3. Symbol definitions for structure diagrams.

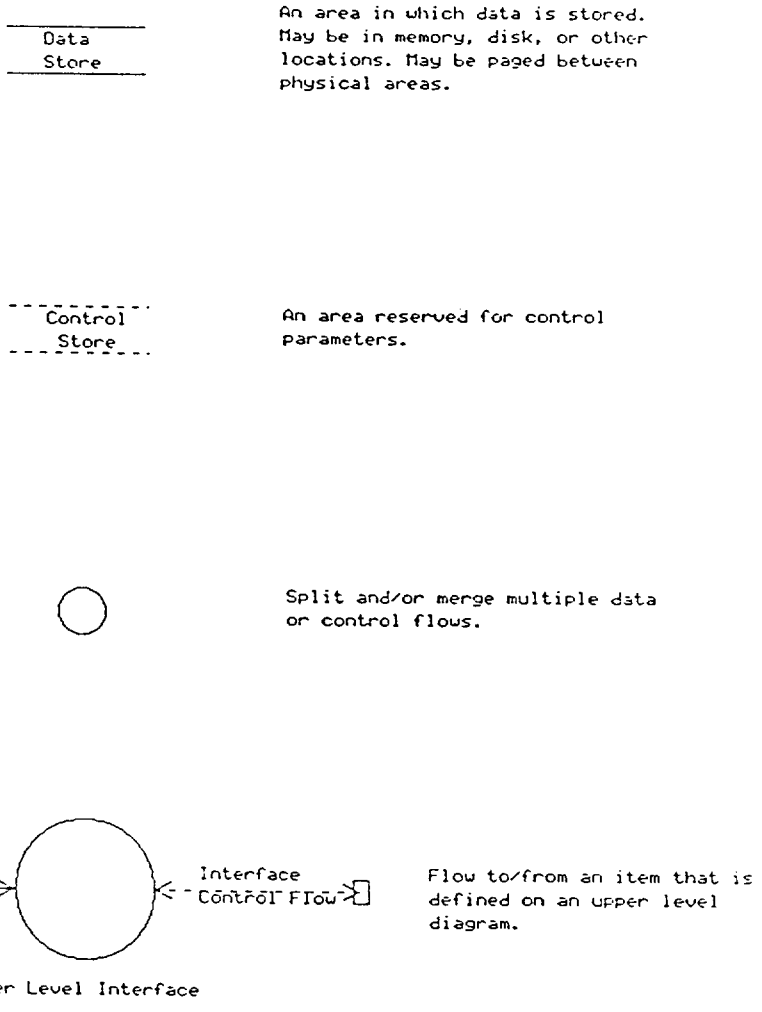


Figure 3 continued.

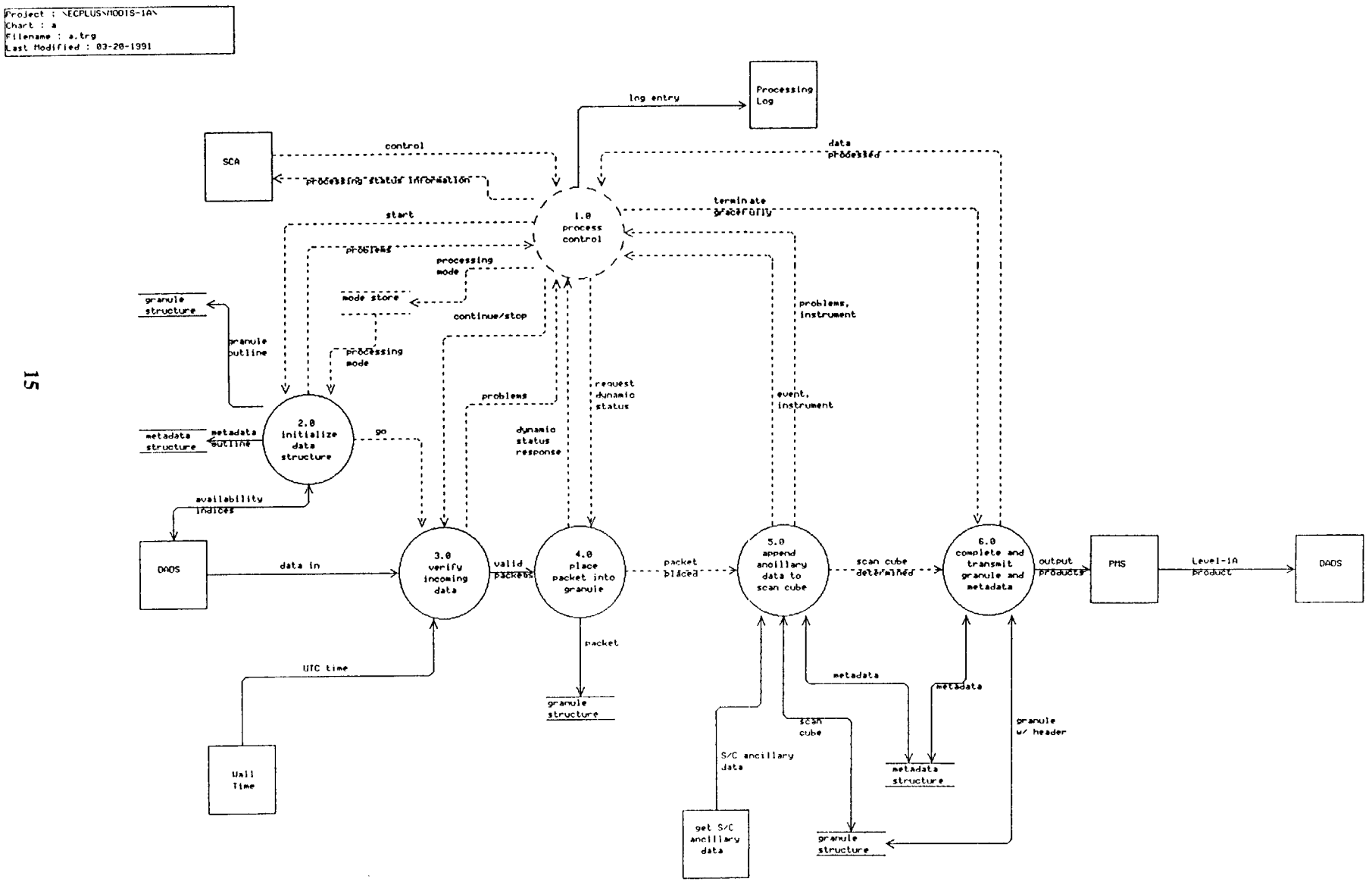


Figure 4. Highest level data flow diagram of MODIS Level-1A processing system including interactions with external entities.

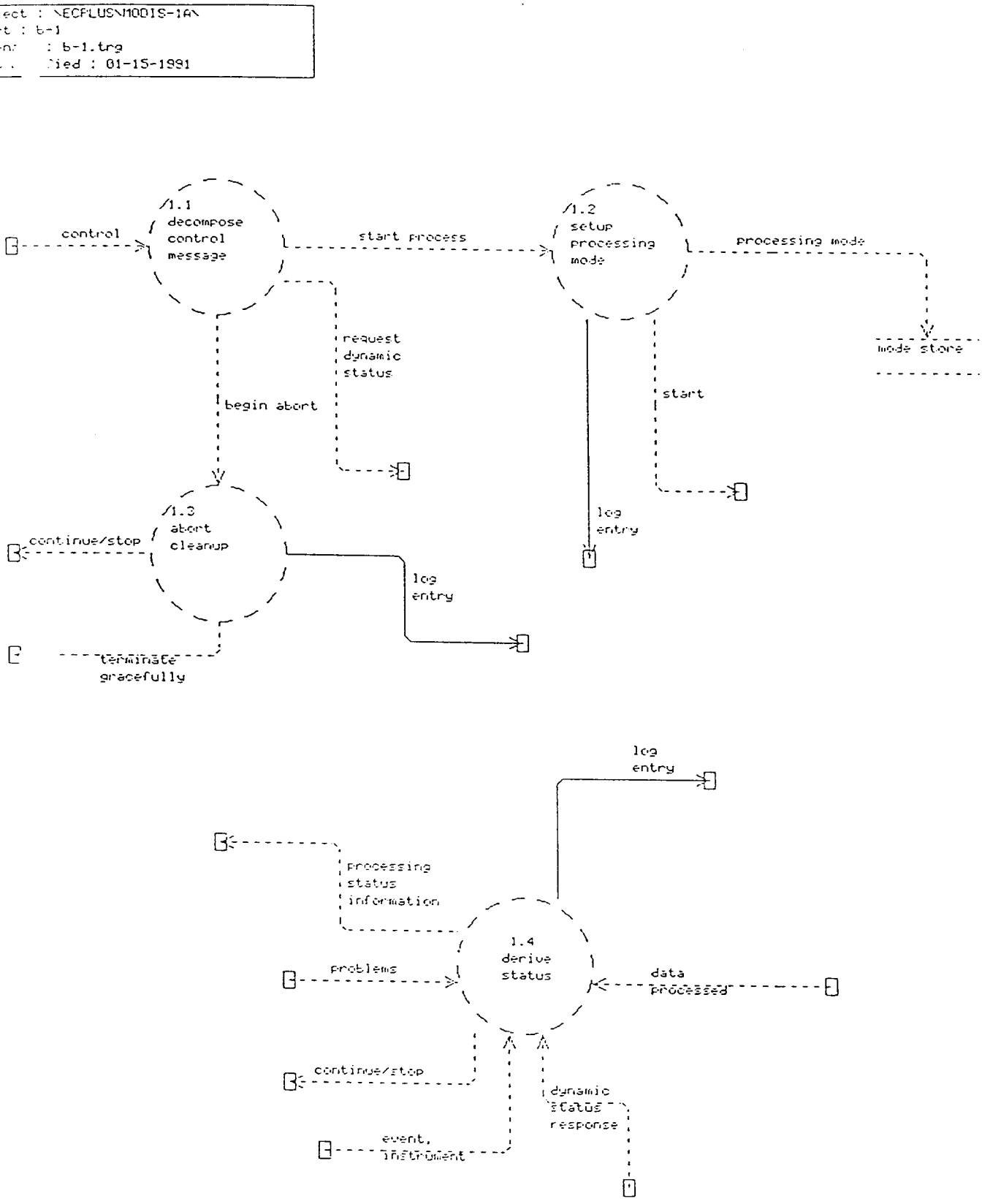


Figure 5. Data flow diagram for Function 1.0: Process Control

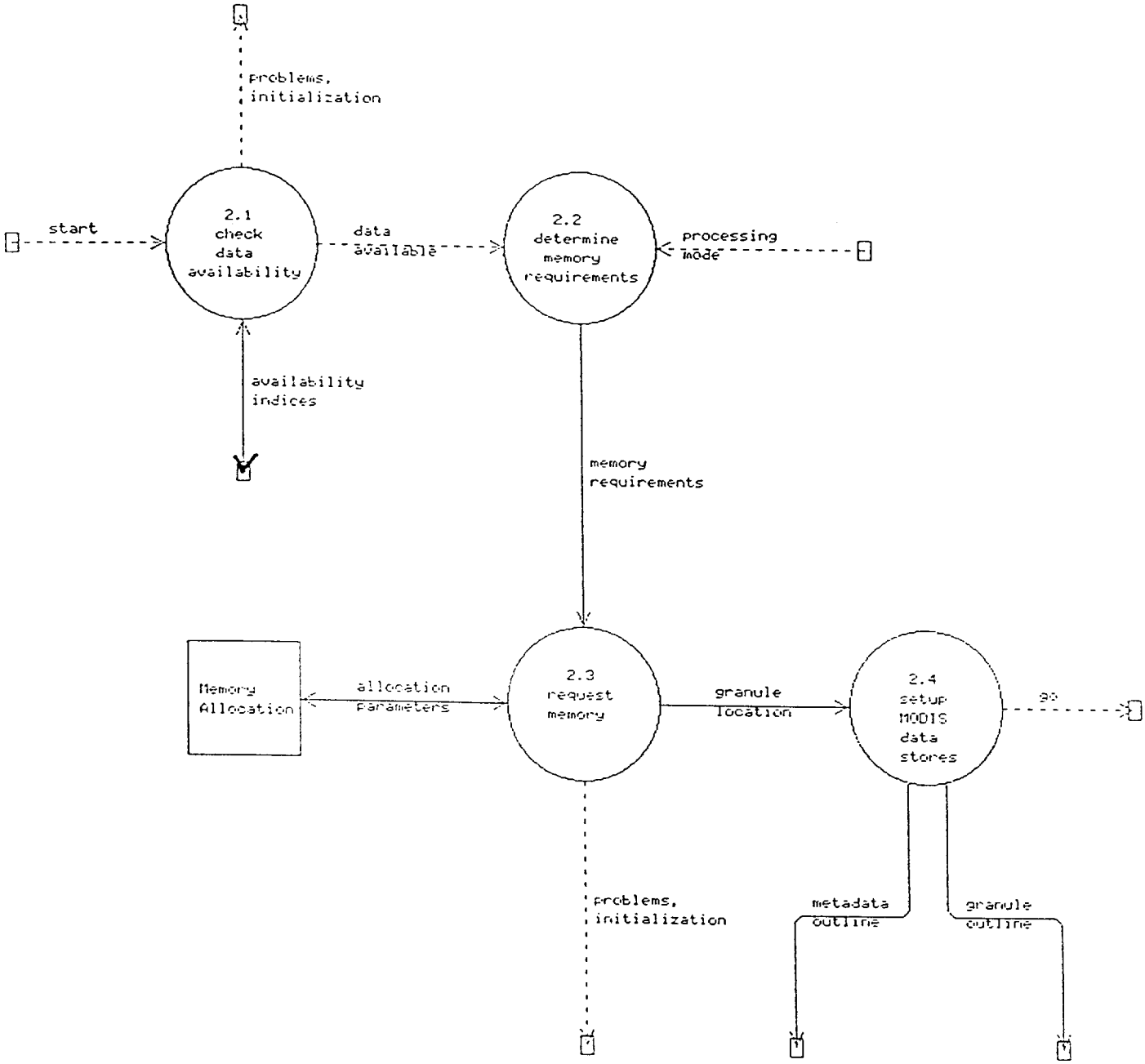


Figure 6. Data flow diagram for Function 2.0: Initialize Data Structure

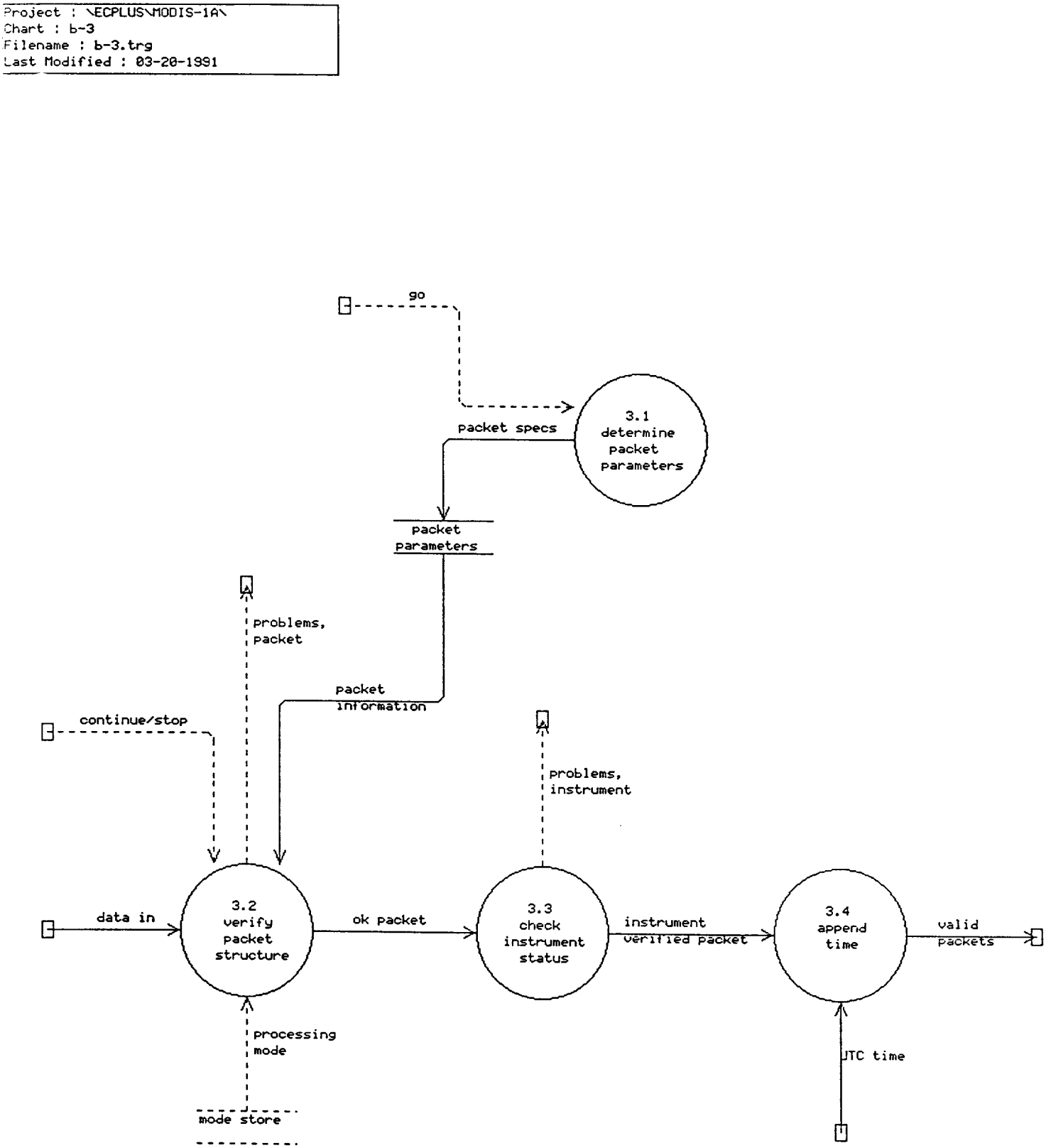


Figure 7. Data flow diagram for Function 3.0: Verify Incoming Data

ject : \ECPLUS\MODIS-1A\
t : b-4
name : b-4.trg
M ied : 01-17-1991

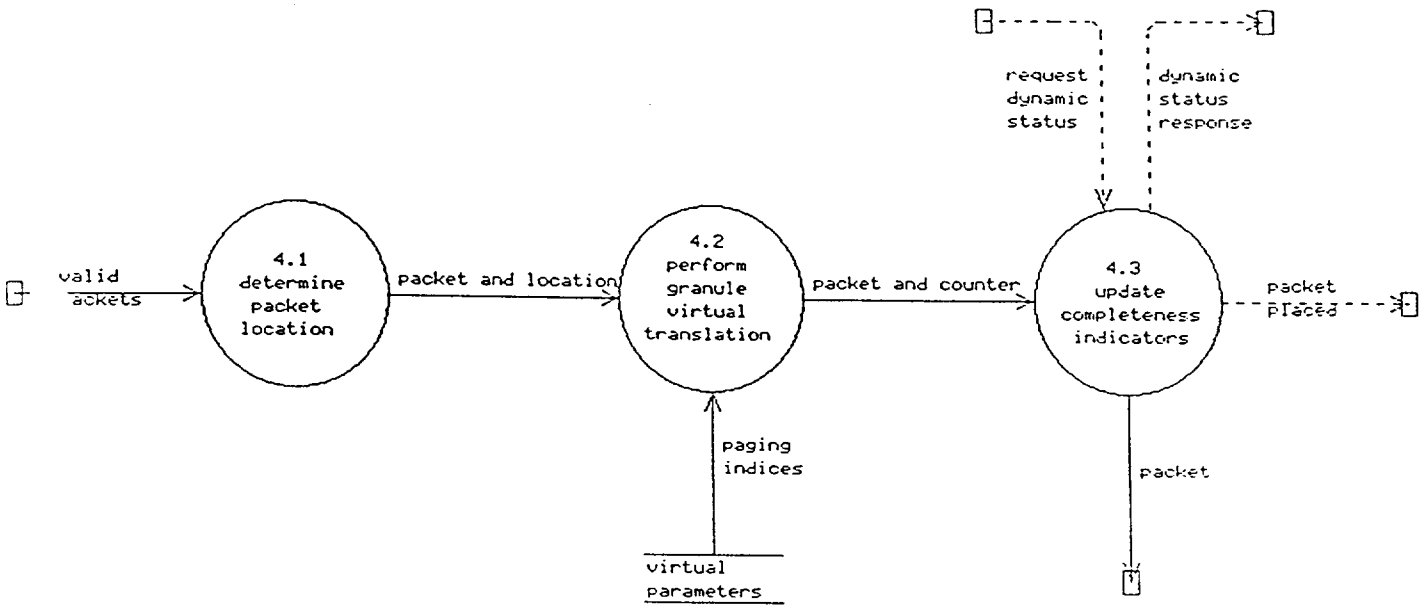


Figure 8. Data flow diagram for Function 4.0: Place Packet into Granule

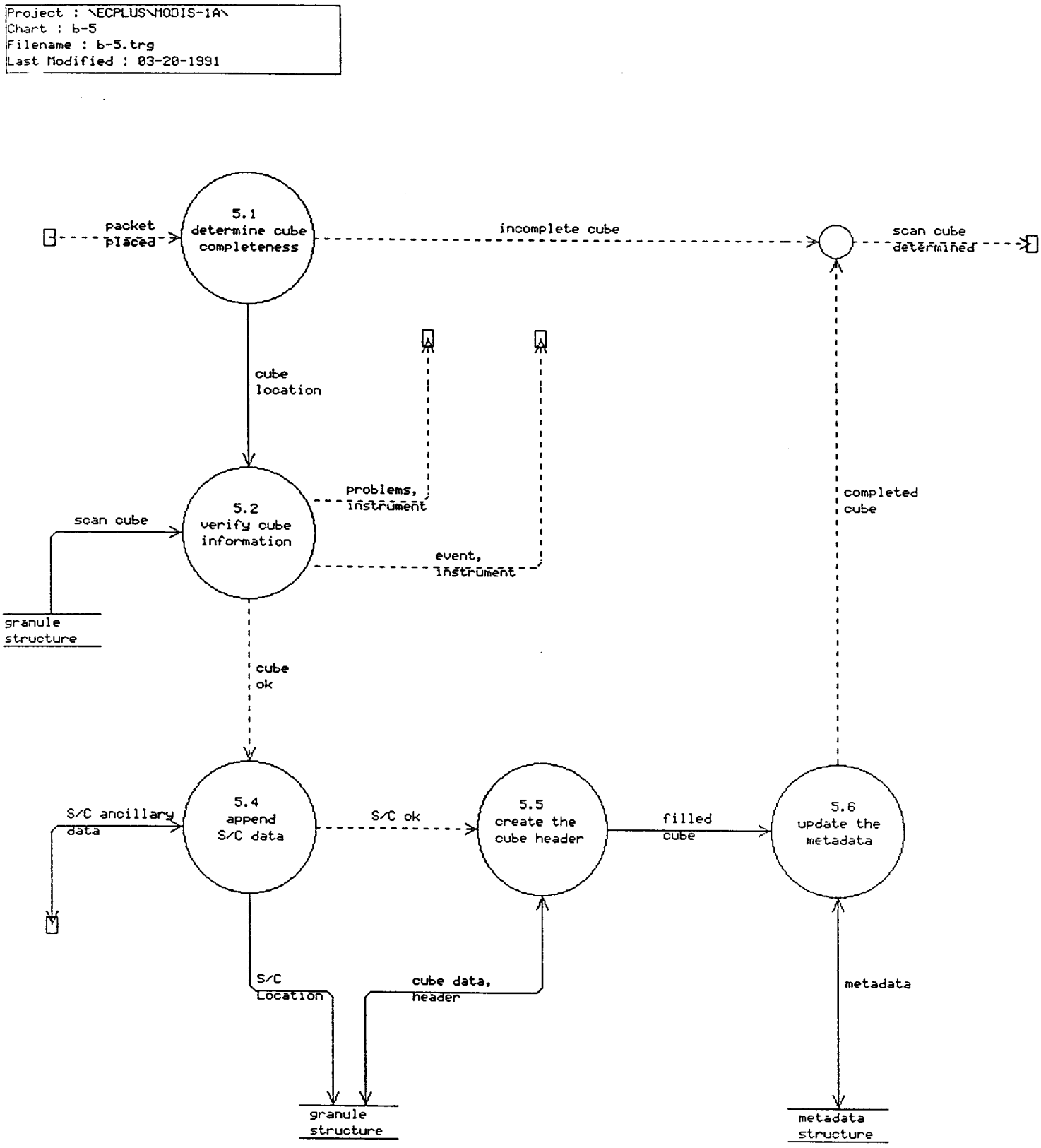


Figure 9. Data flow diagram for Function 5.0: Append Ancillary Data to Scan Cube

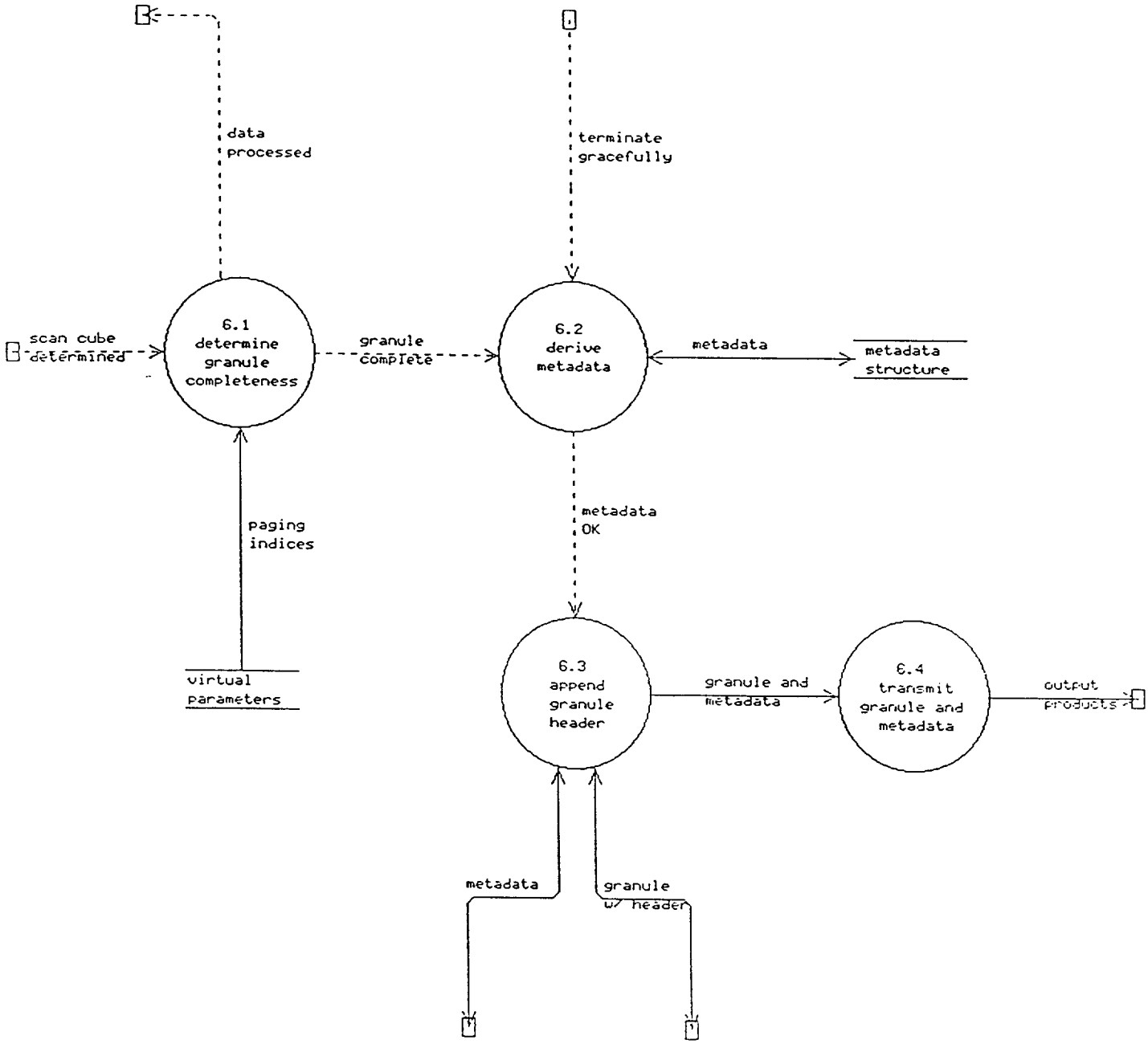


Figure 10. Data flow diagram for Function 6.0: Complete and Transmit Granule and Metadata

MODIS LEVEL-1A DATA DICTIONARY

Abort Cleanup
Type: Control Transform
Location: 1.3

Processes termination messages into the proper flow control items: either a graceful termination (all files written and closed) or abort-now condition (immediate termination without closing files). Posts an entry to the Processing Log.

Allocation Parameters
Type: Data Flow
Location: 2.2 Memory Allocation

The dimensions of the storage allocation and file types required for Level-1A execution, sent to the operating system. Returns file names.

Append Granule Header
Type: Data Process
Location: 6.3

Append the granule header to the granule structure. This will include information pertaining to the granule as a whole (e.g., starting and ending time of the granule, number of valid scan cubes, etc.).

Append Instrument Status & Anomaly
Type: Data Process
Location: 5.3

Append Instrument Status Information (especially operating mode) for the time applicable to the scan cube along with any anomaly indications (discrepancies between this information and the instrument information contained in the Level-0 header).

Append S/C Data
Type: Data Process
Location: 5.4

Append spacecraft ancillary data to the scan cube. Data corresponding to the approximate time of the scan cube is appended here, not necessarily the exact scan cube time.

Append Time
Type: Data Process
Location: 3.4

Append current operating system UTC time to the packet. This will be used to create an audit trail and the processing log.

Append Ancillary Data to Scan Cube
Type: Data Process
Location: 5.0

Test for a completely filled scan cube of data, append instrument status information and S/C ancillary data to the scan cube, create the scan cube header, and update selected metadata values.

Availability Indices
Type: Data Flow
Location: DADS 2.1

Sends time to the DADS and returns data containing a map of the dataset sizes and completeness. Used to determine if the MODIS Level-1A processing can be performed.

Begin Abort
Type: Control Flow
Location: 1.1 1.3

An indicator to begin an orderly abort of the processing. Specifies either a graceful termination or an immediate abort (see Abort Cleanup).

Check Data Availability
Type: Data Process
Location: 2.1

Performs a verification that the data (Level-0 data, Instrument Status Information and S/C ancillary data) are available in the DADS.

Check Instrument Status
Type: Data Process
Location: 3.3

Examines the Instrument Status Information for operating status and mode.

Complete and Transmit Granule & Metadata
Type: Data Process
Location: 6.0

Tests for granule completeness, performs final accounting at the granule level, fills in remaining metadata items, determines and applies the granule header, transmits granule and metadata, and deallocates memory and disk stores.

Completed Cube
Type: Control Flow
Location: 5.6

A message that the scan cube is complete and the granule has been updated. The message contains the scan cube location description. It is merged with the "incomplete cube" message to form the "scan cube determined" message, which is passed to Function 6.0.

Continue/Stop
Type: Control Flow
Location: 1.3 3.2

An indication to continue or stop processing data. Ask for the next packet, or stop asking for packets from the DADS.

Control
Type: Control Flow
Location: SCA 1.1

A message that informs the process to start, cancel, suspend, resume, and to request and return status (dynamically or statically).

Create the Cube Header
Type: Data Process
Location: 5.5

Determine all the items to be placed in the header of a scan cube, including completeness indicators.

Cube Data, Header
Type: Data Flow
Location: 5.5 Granule Structure

The scan cube data and header information for the completed cube of MODIS data.

Cube Location
Type: Data Flow
Location: 5.1 5.2

The memory location of the completed scan cube. This cube must be in memory, not in the disk backing store.

Cube OK
Type: Control Flow
Location: 5.3 5.4

An indication that the instrument status information and any anomalies have been successfully appended to the scan cube of data.

DADS
Type: External Entity
Location: External

Data Archive and Distribution System; an ECS function/system.

Data Available
Type: Control Flow
Location: 2.1 2.2

A message indicating that the data required to process this granule is available from the DADS.

Data In
Type: Data Flow
Location: DADS 3.2

Level-0 data or quick-look data in packet (sub-cube) form.

Data Processed
Type: Control Flow
Location: 6.1 1.4

An indication that the process system is ready for the next packet. It will also contain an indicator of granule completeness and any error conditions.

Decompose Control Message
Type: Control Transform
Location: 1.1

Parses the incoming message to determine message type and where to send it.

Derive Metadata
Type: Data Process
Location: 6.2

Determines all the final metadata values to be placed into the metadata store. If CDOS supplies a management information record (MIR) or a post-event record (PER), then it will be appended to the MODIS metadata product.

Derive Status
Type: Control Transform
Location: 1.4

Handles problem and event messages as well as termination messages, posts the system processing log message and passes a message to SCA.

Determine Cube Completeness
Type: Data Process
Location: 5.1

Checks completeness flags to see if this scan cube has all its packets. This process is expedited by a preliminary accounting of the number of subscans placed in this cube.

Determine Granule Completeness
Type: Data Process
Location: 6.1

Determines if the entire dataset granule has been filled. If so, send a message to the SCA to terminate, but allow further packets to be processed. This allows duplicate packets to be handled and accounted.

Determine Memory Requirements
Type: Data Process
Location: 2.2

Calculates the memory and backing store size requirements as a function of the requested input dataset size, mode, or other parameters.

Determine Packet Location
Type: Data Process
Location: 4.1

Extracts the packet and scan cube number from the packet.

Determine Packet Parameters
Type: Data Process
Location: 3.1

Sets up and fills the store area with the parameters necessary to verify the packet integrity. These packet parameters are derived from SCA information.

Dynamic Status Request
Type: Control Flow
Location: 1.1 4.3

A request from the SCA that processing information be posted into a return message. See Dynamic Status Response.

Dynamic Status Response
Type: Control Flow
Location: 4.3 1.4

An internal message to the SCA that indicates the current status (accounting) of the data processing task.

Event, Instrument
Type: Control Flow
Location: 5.3 1.4

An anomaly has been detected in instrument status between instrument status information and the Level-0 header, or a similar non-catastrophic problem. Does not require immediate attention.

Filled Cube
Type: Data Flow
Location: 5.5 5.6

A scan cube of data that has been filled with all data from the satellite, including the cube header. Metadata and scan cube completeness indicators to follow.

Get S/C Ancillary Data
Type: External Entity
Location: External

A external process that returns platform ephemeris and attitude data in the neighborhood of the requested time.

Go

Type: Control Flow
Location: 2.4 3.1

An indication that tells the processor that the store areas have been defined and that data processing can begin.

Granule Complete

Type: Control Flow
Location: 6.1 6.2

An indication that a granule of data is complete and that metadata determination can begin.

Granule Outline

Type: Data Flow
Location: 2.4 Granule Structure

Addresses, sizes, and types of the MODIS granule store area. This includes disk and memory areas. The store area values are initially defined with invalid data.

Granule Structure

Type: Data Store
Location:

The storage area for the dataset granule consisting of multiple scan cubes, multiple scan cube headers, and a granule header. A scan cube consists of instrument science and engineering data.

Granule and Metadata

Type: Data Flow
Location: 6.3 6.4

The completed granule and the completed metadata.

Granule w/Header

Type: Data Flow
Location: 6.3 Granule Structure

The completed granule with the header, containing information pertaining to the granule as a whole.

Incomplete Cube
Type: Control Flow
Location: 5.1 6.0

An indication that a scan cube has not been completed. More packet data are required.

Initialize Data Structure
Type: Data Process
Location: 2.0

Setup the memory areas (both memory and disk) for the output products (dataset granule and metadata).

Instrument Record
Type: Data Flow
Location: Get Instrument Status 3.3,5.3

The current state of the MODIS instrument at the specified time. This is an integration of all previous status commands, not a history of status events.

Instrument Verified Packet
Type: Data Flow
Location: 3.3 3.4

An OK packet with time tag added and instrument status.

Level-1A Product
Type: Data Flow
Location: PMS DADS

MODIS Level-1A products, verified by PMS (IMS) which are then passed to the DADS for dissemination.

Log Entry
Type: Data Flow
Location: 1.2,1.4 Processing Log

A record to be posted in the ECS (or other) master Processing Log. This leaves an audit trail in the legal sense.

Memory Allocation
Type: External Entity
Location:

An operating system memory (and disk) allocation routine. A process requests storage allocation and the system returns error or location parameters.

Memory Requirements
Type: Data Flow
Location: 2.2 2.3

The derived size of the Level-1A storage area needed to process this granule of data.

Metadata
Type: Data Flow
Location: 5.6 Metadata Structure

Information derived from datasets that provides an understanding of the content or utility of that dataset.

Metadata OK
Type: Control Flow
Location: 6.2 6.3

An indication that final granule metadata processing is complete.

Metadata Outline
Type: Data Flow
Location: 2.4 Metadata Structure

Addresses, sizes, and types of the metadata store allocation. This is used to set up the metadata memory area and initialize that area with predefined values representing invalid data.

Metadata Structure
Type: Data Store
Location:

The storage area for the MODIS Level-1A metadata values.

Mode Store
Type: Control Store
Location: 1.0

A store containing all information necessary to determine the scope of processing to be performed (i.e., begin and end time, number of packets, mode, etc.).

OK Packet
Type: Data Flow
Location: 3.2 3.3

A packet containing a flag indicating that it is correct.

Output Products
Type: Data Flow
Location: 6.4 PMS

MODIS Level-1A data product consisting of metadata and the Level-1A data granule. This can be a standard, quick-look, or reprocessed product.

PMS
Type: External Entity
Location:

Product Management System - Performs management of processed data, adds further data quality information before passing the data to the DADS.

Packet and Counter
Type: Data Flow
Location: 4.2 4.3

The packet, along with the packet number and scan cube number. The counter determines the location of this packet in the granule so that the packet is placed in its correct location within the correct scan cube.

Packet Information
Type: Data Flow
Location: Packet Parameters 3.2

Size, ID location, etc. of packet structure parameters which are to be used to verify that the correct packets have been received from the DADS.

Packet and Location
Type: Data Flow
Location: 4.1, 4.2

The packet along with the location within the correct scan cube within the granule where the packet will be placed.

Packet Parameters
Type: Data Store
Location:

A storage area containing specifiers of the packet size, ID, etc.

Packet Placed
Type: Control Flow
Location: 4.3 5.1

A packet (subcube) of data has been placed into the proper granule location in memory, paging if necessary.

Packet Specifications
Type: Data Flow
Location: 3.1 Packet Parameters

Packet parameters to be used for verification of the packet integrity (not instrument data).

Paging Indices
Type: Data Flow
Location: Virtual Parameters 4.2

Internal pointers and flags that are used to manage the virtual to/from physical addressing of the MODIS granule structure.

Perform Granule Virtual Translation
Type: Data Process
Location: 4.2

Determine if the scan cube location for this packet is currently in memory. If not, perform the physical/virtual memory mapping with scan cube posting if required.

Place Packet into Granule
Type: Data Process
Location: 4.0

Determines packet location, performs granule virtual translation, and updates completeness indicators.

Problems
Type: Control Flow
Location: 2.1, 3.2, 3.3, 5.2, 1.4

These messages can signal an end of data input, signal bad or inappropriate data, request an alarm generation, or other potentially catastrophic (probably stop processing) problems. These are alarm messages.

Problems, Initialization
Type: Control Flow
Location: 2.1, 1.4

A message indicating that a potentially catastrophic problem has been detected, such as not enough store space to process the data. This is an alarm, not an event.

Problems, Instrument
Type: Control Flow
Location: 3.3,5.2 1.4

A serious instrument discrepancy has occurred (i.e., turned off). This is an alarm, not an event.

Problems, Packet
Type: Control Flow
Location: 3.2 1.4

An alarm message: the process has encountered the last packet, or has encountered a bad/illegal packet.

Process Control
Type: Control Transform
Location: 1.0

Handles the control functions of the processor. Interfaces with the context environment via the ECS SCA process.

Processing Log
Type: External Entity
Location:

Log of processing status records, time sequential events. This is not the current status but a time based history of status events.

Processing Mode
Type: Control Flow
Location: 1.2 ModeStore

A message containing the mode of processing to be performed. (i.e., standard processing, reprocessing, or quick-look.)

Processing Status Information
Type: Control Flow
Location: 1.4 SCA

Information regarding the fault conditions and processing performance of this processor. Status or completion information from the MODIS process to the SCA. May be abnormal, dynamic, or normal termination messages.

Request Memory
Type: Data Process
Location: 2.3

Ask the operating system for system resources to allow processing of this dataset. This includes processor and disk memories.

S/C Ancillary Data
Type: Data Flow
Location: Get S/C Ancillary Data 5.4

Spacecraft ephemeris and attitude data obtained from a database within the EOSDIS system.

S/C OK
Type: Control Flow
Location: 5.4 5.5

An indication that the spacecraft ephemeris and attitude data have been appended to the proper scan cube structure.

SCA
Type: External Entity
Location:

Schedule, Control, Accounting. An ECS process to perform scheduling of Product Generation System (PGS) programs.

Scan Cube
Type: Data Flow
Location: 5.2

A set of MODIS instrument data that corresponds to a sweep of the instrument mirror or other scanning device. A scan cube has three dimensions: along track, across track, and wavelength.

Scan Cube Determined
Type: Control Flow
Location: 5.0 6.1

All tests for a completed scan cube have been performed, no judgement is made of the results of these tests.

Scan Location
Type: Data Flow
Location: 5.2 5.3

An indication that the instrument data within a scan cube has been processed and that additional scan items need further processing.

Setup MODIS Data Stores
Type: Data Process
Location: 2.4

Determine and initialize all Level-1A stores - either in memory or on disk as needed.

Setup Processing Mode
Type: Control Transform
Location: 1.2

Derives the mode parameters, posts an entry to the system Processing Log, and starts the show.

Start
Type: Control Flow
Location: 1.2 2.1

Starts the process with initialization parameters from which the store sizes can be calculated.

Start Process
Type: Control Flow
Location: 1.1 1.2

The result of an "initiate processing" message type being passed to the MODIS processor from the SCA.

Terminate Gracefully
Type: Control Flow
Location: 1.3 6.2

An indicator that instructs the process to finalize any remaining products, clean up and return data stores to the operating system, and post/close any files used.

Transmit Granule and Data
Type: Data Process
Location: 6.4

Pass either the data products (meta and granule), or pointers to the products, to the external EOSDIS PMS processor for ultimate inclusion in the DADS after IMS validation input.

UTC Time
Type: Data Flow
Location: Wall Time 3.4

ECS universal time. Used to time stamp processor log entries and data packets (for inclusion in the data cube).

Update Completeness Indicators
Type: Data Process
Location: 4.3

Set the bit for this packet location in the scan cube that indicates that these data have been found. If a dynamic status has been requested, generate a response accounting message.

Update the Metadata
Type: Data Process
Location: 5.6

Make any of the necessary metadata items current. An update process.

Valid Packets
Type: Data Flow
Location: 3.4 4.1

Packets of subcube data that have passed packet, not data, sanity checks such as instrument ID, packet size, etc.

Verify Cube Information
Type: Data Process
Location: 5.2

Perform a verification of data unique to the concept of a scan cube. This may be expanded to include noise analysis, A/D conversion verification, data orthogonality, etc.

Verify Incoming Data
Type: Data Process
Location: 3.0

Perform sanity checks on the raw packets for packet integrity and instrument preliminary condition, and append a time stamp.

Verify Packet Structure
Type: Data Process
Location: 3.2

Check for correct packet size, ID, CRC, and other sanity checks. Instrument data is not included here.

Virtual Parameters
Type: Data Store
Location:

An internal store used to keep track of all counters and flags associated with the concept of a virtual demand paged storage allocation. This allows user defined page sizes which are each expected to be several MegaBytes in length.

Wall Time
Type: External Entity
Location:

An ECS or operating system service that returns the current time.

ASSUMPTIONS LIST
FOR MODIS LEVEL-1A PROCESSING SYSTEM

1. Data will be stored as granules with a granule header. These granules are larger than the scan cube but no larger than an orbit.

Justification: Many data processing activities are facilitated by the creation of data granules of reasonable size -- memory and storage can be allocated, and processing software is easier to write and handle. Granules must be created at Level-1A to produce metadata, a required output product, which will be in granule format in order to describe a coherent part of the data. Reasonably-sized granules also facilitate the recovery of data quality information, particularly the data completeness and existence parameters. Such granules have been used for many satellite sensors, with apparent success. Finally, and perhaps most importantly, reasonably-sized granules are convenient, both in the data system design but also to users, who are adjusted to operating with coherent sets of data.

2. MODIS packets will be provided with a secondary header that includes a packet sequence counter, and a scan sequence counter (which increments once for each instrument scan). The packet will be given a sequence number (packet count) that starts at 1 for the first packet in time (placed at the beginning of each scan cube) and increments until the end of the scan cube. Each packet of data will be placed in its correct time-ordered sequence within the scan cube.

Justification: This information is required to insert packet data into the proper location in the granule structure. It will be used to re-order the packets that may have been scrambled in transmission. This capability is required for the processing of quick-look data and will be handled by default in the processing of standard or reprocessed data.

3. A packet of MODIS data will not be spread across more than one scan cube. This implies that the scan cube boundaries coincide with the packet boundaries.

Justification: A variable-block packetization scheme is inefficient and unlikely.

4. MODIS processing will not compare the instrument operating status as contained in the Level-0 data header with that contained in the Instrument Status Information.

Justification: Instrument Status Information will not be available for 2 days following the downloading of Level-0 data. Furthermore, it is the ICC's responsibility to monitor the health and safety of the instrument. Section 6.5.2.1.2 of the ECS Specifications, Telemetry Processing Service, states

> "The ICC provides health and safety monitoring for its instrument. It receives real-time or playback observatory housekeeping data and instrument engineering data directly from CDOS. For some instruments, instrument engineering data received from CDOS may be embedded in science packets,

from which the ICC will have to extract the instrument engineering data. The ICC extracts the relevant platform parameters and instrument housekeeping data from the observatory housekeeping data stream. The ICC uses these data for both short-term instrument health, safety, and performance monitoring activities, and for instrument trend monitoring."

5. MODIS Quick-Look processing may require time-ordering, redundancy elimination, and quality control measures not required for standard MODIS processing.

Justification: CDOS may not be able to provide routine processing services that meet Quick-Look data timeliness constraints.

6. All data packets with an Application Process ID[1] that designates MODIS data will be retained in the MODIS Level-1A product.

Justification: Data addressed to MODIS will not be retained by any other instrument service.

7. Level-1A processing is reversible, but not necessarily to re-create Level-0 data as it was originally stored in the DADS. Instead, re-created Level-0 data may be time-ordered packets of original data.

Justification: The time-ordering process in the Level-1A processing scheme will not keep track of the order in which Level-0 data were originally stored, thus exact reversibility is impossible. Furthermore, duplicates will be removed, thus also making exact reversibility impossible. However, the spirit of the reversibility requirement is to be able to recover the full set of instrument data. Our processing scheme meets this test. However, if Level-0 data is processed by CDOS as stated in the ECS Requirements Document, i.e., time-ordered data with duplicates removed, then our processing involves no additional time-ordering or duplicate removal, and exact reversibility is achievable.

8. Reversibility of Level-1A processing will be achieved through a separate program.

Justification: A separate program for reversibility is necessary to simplify the description and design of a Level-1A system.

9. Spacecraft ancillary data will be obtained in a process external to the MODIS Level-1A processing.

Justification: These data are required for all EOS instruments, not just MODIS.

---

[1]Packet address field as defined in "Packet Telemetry", CCSDS 102.0-B-2, CCSDS Secretariat, Code TS, NASA, Washington, D.C.

10. The Level-0 data packets and the MODIS program backing stores[2] should be local to the computer performing the MODIS processing.

Justification: To optimize program execution.

11. MODIS processing will compare and evaluate instrument engineering values at both the packet processing stage and at the scan cube processing stage.

Justification: Selected instrument engineering data used to derive characterization quality indications can not be determined until the entire scan cube of data has been received. This implies that an engineering parameter may be more than a single byte in length and may be divided and transmitted in two data packets. If an instrument engineering item is represented by a single byte or smaller value, checking can be performed at the packet level (assuming packet byte alignment). As the philosophy of Level-1A processing is to place all engineering and science data packets into the data granule structure, there may exist a scan cube with missing data somewhere in the scans or bands. MODIS Level-1B processing may need valid engineering data for calibration reasons, but Level-1A does not. Level-1A will not alter any data. In summary, science data is not checked upon completion of a scan cube, only selected engineering data.

[2]The MODIS system will function with two scan cubes in physical memory with the remaining scan cubes of the granule stored on-line.

EXTERNAL INTERFACE DOCUMENT
FOR MODIS LEVEL-1A PROCESSING SYSTEM

This document describes the control and data interfaces between the MODIS Level-1A processing system and external functions, datasets, and services. The external entities are represented in Figure 4 as squares. Most of the services belong to ECS (EOSDIS Core System). Since not all of the ECS functions are completely described and many are subject to change, the MODIS Level-1A interfaces to these services must be considered preliminary. Many of the interfaces stated here are assumptions on our part. Assumptions not dealing with external interfaces are contained in the Assumptions List.

1. ECS SERVICES

1.1 Scheduling, Control, and Accounting (SCA)

The SCA interfaces with the MODIS Level-1A processing system in two ways: 1) it serves as control to the MODIS system (it sends messages to the MODIS system) and 2) it receives processing status information (it receives messages from the MODIS system. All messages go through an internal MODIS process control (Function 1.0 in the data flow diagrams) before going to the SCA.

1.1.1 Control. The SCA external entity is the master controller of the ECS Product Generation Systems (PGS), of which MODIS is a component. This SCA function controls the MODIS data processor by four methods (see Functional Requirement B, and associated data dictionary): 1) initiate execution, 2) suspend execution, 3) resume execution, 4) cancel execution, 5) request processing status information, and 6) select processing mode. Processing status information includes a "dynamic status request". These controls are implemented as messages to the MODIS processor.

a. Initiate Execution: This is a message that the MODIS system obtains from the SCA to begin performing any actions. The message contains information the quantity of data to be produced (output granule size), possibly the packet parameters and instrument IDs, and a file name (or other indicator) indicating the location of the MODIS Level-0 Data with its associated ancillary data (either as a metadata file or special record with the Level-0 Data).

b. Suspend Execution: Tells the MODIS system to stop processing -- no shutdown procedures are enacted (i.e., close data files), nor are any messages sent to SCA.

c. Resume Execution: This message can follow either a "suspend execution" message or a "terminate gracefully" message (described later). In either case, the MODIS system picks up where it left off and continues processing.

d. Cancel Execution: This is an asynchronous message generated by the SCA that tells the MODIS processor to perform a termination of processing. The

contents of this message indicate an abort termination or a graceful termination. The MODIS processor returns a post-processing message indicating that the requested termination has been performed. The MODIS process can then be removed from memory or restarted as necessary. A restart involving an abort termination requires an "initiate execution" message, while a graceful termination message is usually followed by a "resume execution" message.

e. Dynamic Status Request: This is a message sent to the MODIS system indicating that a dynamic status response message is to be generated. The MODIS system looks for the presence of this request message at selected points in the data flow processing by interrogating the operating system. If a message is present, a return message is generated. The request message can be generalized (enhanced) by adding parameters that indicate the format or content of the MODIS processor generated response message.

f. Select Processing Mode: A message generated before the "initiate execution" message that determines the type of processing to be done, i.e., standard, reprocessing, or quick-look.

1.1.2 Status

The MODIS Level-1A processing system is required to send the SCA processing performance (see Functional Requirement C) and fault (exception) conditions. Processing performance messages include post-processing reports and dynamic status response, which are solicited by the SCA and fault conditions include alarms and events, which are unsolicited messages.

a. Post-Processing Report: This is the final accounting message to the SCA that indicates the termination status of the MODIS Level-1A process. It is posted to the operating system for retrieval by the SCA upon MODIS termination. The accounting message contains the file name (location) of the output data granule and metadata products, an indication of the quality of the processing (criteria to be determined), and an indication of the quantity (size) of the data produced.

b. Dynamic Status Response: This response message to a dynamic status request message contains the information necessary for the SCA to determine the processing status upon request. This includes the number of expected and already processed packets, spacecraft (S/C) start and stop times of the completed packets, an estimate of the percentage of granule completion, and an indication of the quantity of data product produced up to this time. An indication of data quality may also be included.

c. Alarm: This is an unsolicited message from the MODIS system to the SCA indicating that a serious problem has occurred within the MODIS system that

could lead to generation of invalid data. The contents of this message indicate the nature and severity of the problem. The message is expected to have indicator flags (predefined error values) as well as a character-based message for operator display. Alarms are called problems in the diagrams and the data dictionary.

d. Event: This is another form of an unsolicited message from the MODIS system to the SCA. This message contains indicator flags (the meaning of which is pre-determined) for anomalies between the telemetered data and the MODIS Instrument Status Information. An event represents a non-catastrophic occurrence and does not indicate a serious problem with the processing.

1.2 Data Archive and Distribution System (DADS)

The DADS is the primary storage area for MODIS data and the MODIS Instrument Status Information. It may also be the storage place for the spacecraft ancillary data. The MODIS Level-1A program will, using the file name indicated in the SCA "start" message, ask for the MODIS Level-0 Data from the DADS using a normal operating system, file-based, data access query. This will include an indication of the validity of the file record transfer with any error conditions. This is a synchronous transfer using operating system-supplied handshaking.

1.3 Product Management Service (PMS)

The PMS will accept the MODIS Level-1A Data products consisting of the MODIS science and engineering data in MODIS Level-1A granule format, the MODIS Level-1A metadata, and the MODIS Level-1A quick-look products. The data may enter the PMS either directly from the MODIS system or through the SCA. If the data are passed directly from the MODIS system, it will be as file names (pointers). The file names will then be transmitted to the SCA in a termination message and posted in a message to the PMS processor. If the data is passed directly to a concurrent PMS program, then the data records will be transmitted using a handshaking protocol between the PMS and MODIS programs.

2. NON-ECS EXTERNAL FUNCTIONS

2.1 Get S/C Ancillary Data

This function finds the spacecraft ancillary data for appropriate times at its stored or available location. This information is required for navigation and data quality assessments performed at Level-1B processing. For the MODIS Level-1A process, at a minimum, this includes the spacecraft (S/C) ephemeris and attitude information consisting of the ten time-based S/C packets of ephemeris and attitude information localized to the MODIS scan cube time. In addition, there may be a requirement for the scan positions, and operating status of other instruments, since these may affect MODIS observations. Since these data are likely to be required by other sensors, this function may be an EOSDIS function. In this

case, the format of the request to this process will indicate the items of interest to the calling process.

3. EXTERNAL DATABASES/MEMORY

3.1 Processing Log

The Processing Log is a database which is created by the accumulation of status response messages. It is **internal** to the MODIS processing system and applies for all MODIS processing. It is not limited to Level-1A, and so is considered external to the MODIS Level-1A system. The purpose of the Processing Log is to allow other programs and databases to determine when processing has been started, stopped, suspended, or otherwise managed. It is used to prove that the MODIS system has performed certain tasks and when those tasks were initiated and completed.

3.2 Memory Allocation

The Memory Allocation entity (probably the operating system) accepts requests from the MODIS system for computer memory resources, both disk-based and memory-based. A request for disk-based memory will include the size of the disk area required. The external process will return the file name (implying the location) or an error indication. As some operating systems will not pre-allocate disk space, the MODIS program will guarantee pre-allocation by filling the disk space with invalid data. A request for computer memory will contain the size of the memory required; the external entity will return the local addresses or an error condition.

3.3 Wall Time

Operating system current time. The returned current time may be in a compacted format such as milliseconds from the beginning of 1990 (or similar). It is used for internal accounting purposes, for the audit trail, and for the Processing Log.

MODIS LEVEL-1A GRANULE STRUCTURE

In the logical visualization of the Level-1A granule structure, the granule is composed of an integer number of scan cubes. The scan cube, in turn, is composed of an integer number of packets. These three increments of data, the packet, the scan cube, and the granule, form a hierarchy in which the packet is a subset of the scan cube and the scan cube is a subset of the granule. Each increment contains a header describing information that pertains to the increment. The packet header contains the packet ID, start and stop times of the packet, etc. The scan cube header contains start and stop times of the scan cube, the number of valid packets, tilt, etc. The granule has its own granule header appended at the beginning of the granule structure, that contains information pertaining to the granule as a whole (e.g., number of valid scan cubes in the granule, starting and ending times of the first and last scan cubes, etc.).

The scan cube is filled with packets and the granule with scan cubes. The resulting granule structure is shown in Figure 11, illustrating the relationship between the data increments.

The size of a cube of data is $\approx$ 0.5 megabytes for MODIS-N and $\approx$ 1.6 megabytes for MODIS-T. Since the granule is composed of many cubes (an orbit of data would produce $\approx$ 2 gigabytes of MODIS-N data), it is too large to fit into a reasonable amount of computer memory. Thus, to process the incoming granule of data, demand paging is proposed. The computer memory for the data granule is sized to hold two cubes of data at the same time. The remaining cubes of data will be swapped between a disk backing store and the computer memory. It is assumed that sufficient disk storage can be pre-allocated before processing of incoming data begins.

Standard Level-0 data are required to be time-ordered by CDOS. However, there is no such requirement for quick-look data. For quick-look data, the packets are generated at the instrument in a time-ordered sequence but may be received at the EOSDIS facility in a slightly non-time ordered sequence due to the nature of the store and forwarding intermediate data transmission steps. In other words, the locality in time of the arrival of packets will be time-ordered but will include a random small delta time offset. The probability that packets will be placed within one scan cube location in any time interval is large and the probability that sequential packets will be scattered across more than two scan cubes is extremely small. Therefore, keeping two scan cubes in memory at a time will allow an extremely high probability that the cube in which the packet belongs will be in memory. This approach solves the quick-look problem, and comes at small or no cost to standard processing. After the packet is placed, a bit is set.

The backing store is managed by the MODIS Level-1A program and consists of a disk file with random direct access. This disk file will contain the output data product at the completion of the processing, and the ownership of this file can be passed to subsequent processors by name thereby eliminating an actual transfer of data. The metadata file will not have a backing store and must be passed directly.

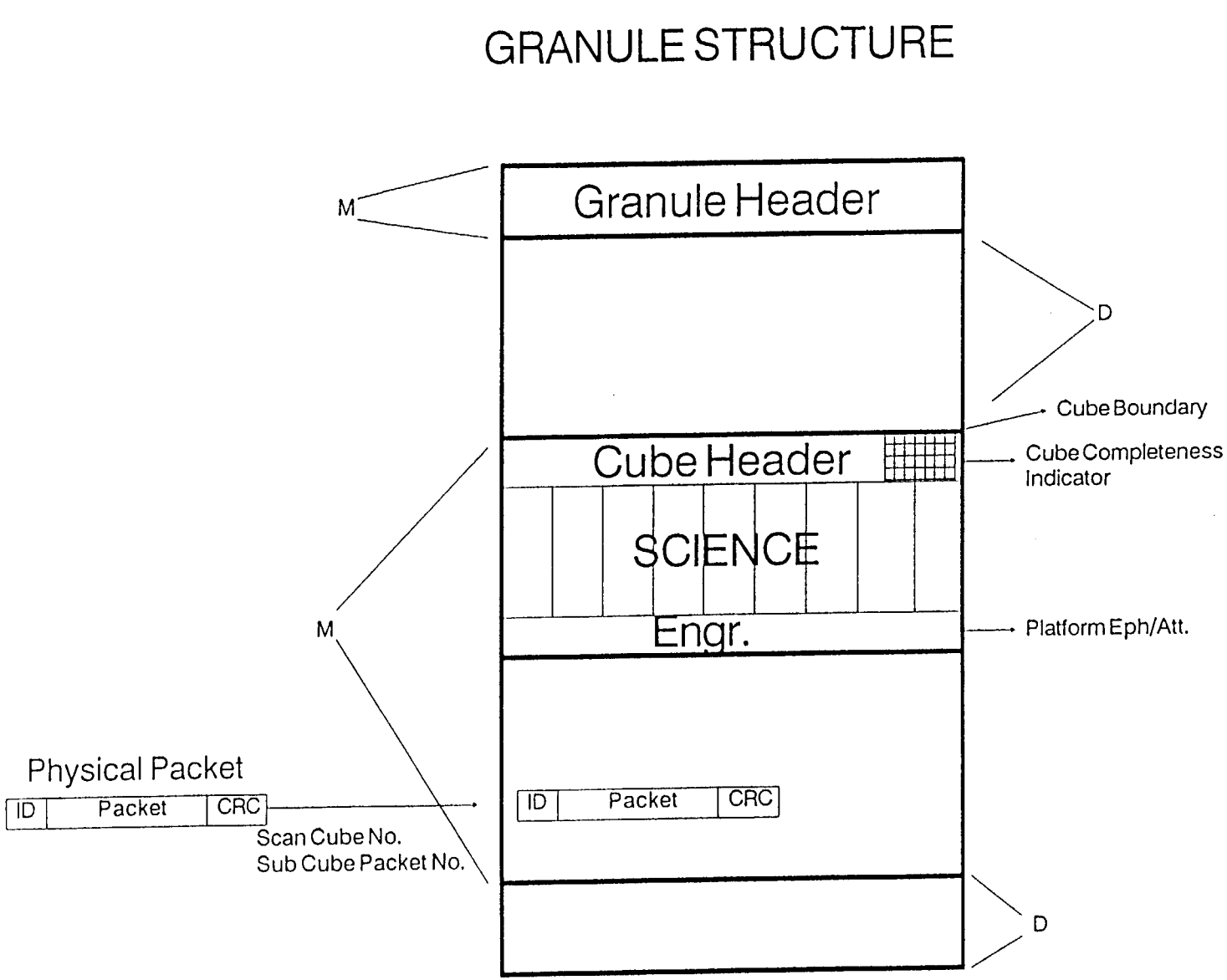


Figure 11. Granule structure showing relationship between packets, scan cubes and granules.

DATA QUALITY INFORMATION PROVIDED
BY MODIS LEVEL-1A DATA PROCESSING SYSTEM

It is an ECS requirement that data quality information be provided by the data processing systems. However, in keeping with our simple and conservative design of the MODIS Level-1A system, data quality information is limited. All data quality information generated by CDOS and contained in the Level-0 data (header or actual data) will be retained and passed through the Level-1A data system.

There are only two types of data quality information generated by the MODIS Level-1A processing system.

1. Data Completeness Information. This is the number of data values processed and available in the data increment (scan cube or granule) for subsequent processing. Scan cube completeness information will include number of scan lines, number of bands, and number of pixels available. Granule completeness information will include number of scan cubes available. This information will be included in the scan cube and granule headers, and in the metadata, and will be sent to the Scheduler and Processing Log.

2. Identity Verification. This is information stating that all indicators in the Level-0 data (i.e., packet ID) show that this is MODIS data, and they are confirmed with the general format of the data. This information will not be retained, but an inconsistency will generate an alarm ("problems, packet") to the Scheduler. Another identity verification check is to assess packet length. Again if the packet does not have the correct length, an alarm is sent.

No data quality check failures will result in cancellation of processing by the MODIS system. All data quality check failures only result in alarm or event messages sent to the SCA with no further action initiated by the system. This emphasizes the conservative nature of the processing design. However, the SCA may request suspension or cancellation at any time based on the messages sent by the MODIS system or for other reasons.

BIBLIOGRAPHY

Functional and Performance Requirements Specification for ECS, Fourth Preliminary, September 14, 1990.